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SUMMARY REPORT

SOIL VAPOR EXTRACTION PILOT TEST AT EXTRACTION WELL VE-04, OPERABLE UNIT-2 (MAY 28 TO DECEMBER 4, 2003) NATIONAL AERONAUTICS AND SPACE ADMINISTRATION JET PROPULSION LABORATORY PASADENA, CALIFORNIA

Contract No. N68711-01-D-6008

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Prepared for:

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Naval Facilities Engineering Command

1220 Pacific Highway

San Diego, California 92132

Prepared by:

GEOFON, INC.

22632 Golden Springs Drive, Suite 270

Diamond Bar, California 91765

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Prepared by: Anthony G. Ford 3/9/04

Anthony G. Ford — Date

GEOFON, Inc.

Senior Geologist

Approved by: 3/9/04

Asrar Faheem, R.E.A. — Date

GEOFON, Inc.

Project Manager

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LIST OF ACRONYMS AND ABBREVIATIONS

bgs:	below ground surface
CCl_4:	carbon tetrachloride
cfm:	cubic feet per minute
1,1-DCA:	1,1-dichloroethane
1,2-DCA:	1,2-dichloroethane
1,1-DCE:	1,1-dichlorothene
FID:	flame ionization detector
GAC:	granular activated carbon
GEOFON:	GEOFON, Incorporated
JPL:	Jet Propulsion Laboratory
NASA:	National Aeronautics and Space Administration
NPL:	National Priorities List
O&M:	operation and maintenance
OU:	Operable Unit
ppmv:	parts per million by volume
PVC:	polyvinyl chloride
RI/FS:	Remedial Investigation/Feasibility Study
ROI:	radius of influence
SCAQMD:	South Coast Air Quality Management District
SVE:	soil vapor extraction
SWDIV:	Department of the Navy Southwest Division
TCE:	trichloroethene
USEPA:	United States Environmental Protection Agency
VOC:	volatile organic compound

1.0 INTRODUCTION

GEOFON, Inc. (GEOFON) is pleased to submit this Summary Report of a soil vapor extraction (SVE) pilot test conducted for Operable Unit 2 (OU-2) (on-facility vadose zone soil) at the National Aeronautics and Space Administration (NASA), Jet Propulsion Laboratory (JPL), Pasadena, California (Figure 1). This report summarizes SVE pilot test operation from May 28 to December 4, 2003 at extraction well VE-04 of OU-2 (Figure 2). The purpose of this report is to document SVE pilot test activities and to provide SVE pilot test program results and conclusions. The SVE pilot test operation and maintenance (O&M) was conducted under the Department of the Navy, Southwest Division (SWDIV) Contract No. N68711-01-D-6008, Delivery Order No. 001.

1.1 Background Information

Based on previous investigations at the JPL site, subsurface soils in OU-2 contain volatile organic compound (VOC) vapors. JPL was placed on the National Priorities List (NPL) in 1992. The Remedial Investigation/Feasibility Study (RI/FS) Work Plan identified the investigative work required to adequately characterize the chemicals in soil. The investigative work identified in the RI/FS Work Plan consisted of installation and sampling of nested soil vapor monitoring wells. The sampling of these wells has indicated the presence of VOC vapors, primarily carbon tetrachloride (CCl_4), Freon 113, and trichloroethene (TCE). These compounds are generally located beneath the north-central portion of the site, and were detected at depths extending to the water table. The groundwater table at JPL ranges up to 200 feet or more below ground surface (bgs). Nonvolatile constituents were not found at concentrations requiring remediation.

A SVE pilot study was initiated at extraction well VE-01 in April 1998 and conducted through June 1998. Based on the results of the initial pilot study, operation of the SVE system was continued from November 1998 to September 1999, from April 2000 to August 2000, and from January 2001 and May 2001. The SVE system was re-started at extraction well VE-01 in December 2001 and continued through June 2002 as part of this extended pilot study of the site. As part of the SVE system operation rotation program (i.e. treatment of different areas using a rotating approach), the SVE pilot study program was continued at extraction well VE-03 from October 30, 2002 to April 30, 2003. The SVE system is estimated to have removed over 200 pounds of VOCs during the pilot study period.

1.2 SVE System Description

The existing SVE system consists of a single extraction well (VE-04), a skid-mounted extraction vacuum blower (with 20 HP motor), moisture separator (50-gallon knockout tank with sight glass, level switch, and safety interlock to shut down blower for high water level), four granular activated carbon (GAC) vessels (each containing 2,000 pounds of vapor phase GAC) in a series-parallel arrangement,

and a dilution air valve, and recirculation air valve to regulate vacuum and flow. Other accessories include a flow meter for measuring flow, magnehelic gauges and U-tube manometers to measure vacuum and vacuum responses, a field flame ionization detector (FID), and vapor sampling equipment.

Extraction well VE-04 is located in the vicinity of soil vapor monitoring wells SVW Nos. 38 and 39. The location of extraction well VE-04 and the soil vapor monitoring wells are shown in Figure 2. Extraction well VE-04 consists of three discrete screened intervals (i.e., three separate casings in the same borehole) with a bentonite seal between screens. The screens are designated shallowest to deepest as VE-04-A, VE-04-B, and VE-04-C, respectively. Each casing is constructed of 2-inch diameter Schedule 80 polyvinyl chloride (PVC) pipe, and is screened (0.020 inch slots) from 12 to 62 feet bgs, 76 to 126 feet bgs, and 140 to 195 feet bgs, respectively. Figure 3 shows the construction details for extraction well VE-04.

Organic vapors are removed from the soil by the vacuum blower and then passed through the moisture separator, in-line filter, and air mixing valve before entering the GAC vessels for treatment. The treated air/vapor is discharged to the atmosphere. The maximum flow rate of extracted soil vapor and ambient air combined is 500 cubic feet per minute (cfm). A piping and instrumentation diagram for the SVE system is shown on Figure 4.

2.0 SUMMARY OF OPERATIONS AND TEST RESULTS

The SVE pilot test at extraction well VE-04 was started on May 28, 2003 for continuous operation. As part of the SVE system startup activity, PneuLog® testing was also performed at the extraction well VE-04 on May 28, 2003 by Praxis to obtain vertical flow profiles, estimate the thickness of the mobile and immobile soil region intervals (layers), and to evaluate if VOC-producing soil layers have been adequately targeted.

The SVE system operated with all three screened intervals (VE-04-A, VE-04-B, and VE-04-C) at extraction well VE-04 through December 4, 2003. The system was shutdown from August 18 through August 31, 2003 during the fifteenth periodic soil vapor monitoring wells sampling activities. After the completion of soil vapor monitoring wells sampling activities, normal operation of the SVE system began on September 1, 2003 without further shutdowns.

Since the SVE system started operation on May 28, 2003, it has yielded an average runtime of approximately 95%. A total of 98 site visits were made during the pilot test duration for sample collection, operation and maintenance, and system optimization. During the pilot test, the flow rate averaged approximately 300 cfm, as measured by the flow meter at an average applied wellhead vacuum of 50 inches of water.

The following SVE system parameters were recorded manually during each site visit: 1) vacuum induced

by the extraction blower, 2) water level in the mist eliminator, 3) vacuum at individual screened interval (VE-04-A, VE-04-B, and VE-04-C), 4) vapor flow rate at each individual screened interval and the influent, 5) FID readings at the influent and effluent, and 6) vacuum responses in soil vapor monitoring wells. The SVE system operating parameters monitoring records are included in Appendix A. A summary of extraction well operating parameters, flow rate, and FID readings are shown in Table 1 and vacuum responses in soil vapor monitoring wells are shown in Table 2.

SVE system influent and effluent (stack) vapor samples were collected in accordance with the South Coast Air Quality Management District (SCAQMD) permit conditions. Each sample was analyzed for VOCs using an FID calibrated to hexane, as required by the SCAQMD.

In addition, the SVE system influent, effluent, and individual screened interval vapor samples were collected once every two weeks over the duration of the SVE pilot test for laboratory analyses. In order to evaluate VOC concentrations during the startup and to select optimal operating conditions, the SVE system influent, effluent, and individual screened interval vapor samples were collected four times during the first week of system start-up at extraction well VE-04 for laboratory analyses. The samples were shipped under chain-of-custody via Federal Express to Air Toxics Ltd. (an environmental analytical laboratory in Folsom, California) for analysis. The samples were analyzed for VOCs by U.S. Environmental Protection Agency (USEPA) Method TO-14. Laboratory results are presented as Appendix B. A summary of laboratory analytical results is presented in Table 3.

During the pilot test at extraction well VE-04, based on the laboratory analytical results, the SVE system influent VOC concentrations ranged from 0.486 to 3.243 parts per million by volume (ppmv), in response to different applied well vacuums. A gradual decrease of influent total VOCs, concentrations was noted from the second day onward following the SVE pilot test start-up. Effluent VOC concentrations ranged from 0.132 to 0.450 ppmv.

The influent Freon 113, CCl_4, TCE, and PCE concentrations ranged from 0.017 to 0.93 ppmv, 0.018 to 0.070 ppmv, 0.150 to 0.870 ppmv, and 0.010 to 0.039 ppmv, respectively. Figure 5A through Figure 5E are graphs of influent VOC, Freon 113, CCl_4, TCE, and PCE concentrations versus calendar time. These graphs represent the decrease of influent VOC, Freon 113, CCl_4, TCE, and PCE concentrations with respect to time.

The VOC influent and effluent emission rate calculations are shown in Table 4. The emission rates were within the permit requirements set by the SCAQMD. The SVE system achieved greater than 99% destruction efficiencies for CCl_4, TCE and PCE. The influent VOC concentrations were combined with flowrate data to construct graphs of influent cumulative pounds of VOCs removed from the subsurface per day versus calendar time (Figure 6A).

Similarly, influent Freon 113, CCl_4, TCE, and PCE concentrations were combined with flowrate data to

construct a graph of influent cumulative pounds of Freon 113, CCl_4, TCE, and PCE removed from the subsurface per day versus calendar time (Figure 6B through Figure 6E).

3.0 RADIUS OF INFLUENCE

Using the data collected during the SVE pilot test, the maximum radius of influence (ROI) and effective ROI were calculated. The "maximum" ROI is the maximum distance in the soil from the test well that is affected by the vacuum applied to the well (i.e., where the vacuum dissipates to zero). Vacuum responses were observed in the soil vapor monitoring well (No. 8) as far as 1,000 feet from the extraction well. The "effective" ROI is the distance from the test well where the vacuum in the soil is equal to a percentage of the vacuum applied to the well (usually assumed to range between 1 and 5 percent). For analysis of this test, a conservative approach was taken, and the effective ROI was calculated at 5% of wellhead vacuum. The average vacuum applied to the test well was 50 inches of water; therefore, the effective ROI would be that distance from the well at which the vacuum in the soil was 2.5 inches of water (0.05 x 50). Therefore, an effective ROI of 450 feet was assumed based on a 50 percent reduction of VOC level in soil vapors at various distances from the extraction well.

4.0 CONCLUSIONS

The following conclusions are based on the results of the SVE pilot test operation at extraction well VE-04 over a period of six months (from May 28 through December 4, 2003), laboratory analysis of soil vapor samples, and site conditions at the time of the test:

- The combined flow rate from the three screened intervals VE-04-A, VE-04-B, and VE-04-C of extraction well VE-04 averaged approximately 300 CFM at an average vacuum of 50 inches of water. The flow rates in screened interval VE-04-A were greater compared to the flow rates in screened intervals VE-04-B and VE-04-C.
- The compound with the highest influent concentration was TCE. The VOC concentrations in the screened interval VE-04-B were greater compared to the concentrations in the screened intervals VE-04-A and VE-04-C.
- A gradual decrease of influent total VOCs, Freon 113, CCl_4, TCE, and PCE concentrations was noted from the second day onward following the SVE pilot test start-up (Figure 5A to Figure 5E). During six months of SVE system operation at the extraction well VE-04, the influent Freon 113, CCl_4, and PCE concentrations were reduced by more than 70 percent and the influent TCE concentrations were reduced by more than 80 percent.
- Total VOC removal rates of up to 0.27 lbs/day were noted. During the six months of operation, approximately 11.35 pounds (cumulative) of VOCs, 1.35 pounds (cumulative) of

Freon 113, 0.91 pounds (cumulative) of CCl_4, 5.35 pounds (cumulative) of TCE, and 0.47 pounds (cumulative) of PCE were removed from the subsurface at extraction well VE-04 by the SVE system.

- The effective radius of influence (ROI) was estimated to be 450 feet.
- The SVE system achieved greater than 99% destruction efficiencies for CCl_4, TCE, and PCE.
- The influent Freon 113, CCl_4, TCE, and PCE concentrations appeared to have reached asymptotic levels (Figure 5B through 5E). During six months of SVE system operation at extraction well VE-04, a significant decrease in TCE concentrations (from 17.0 µg/L-vapor [February 2003] to 8.2 µg/L-vapor [August 2003] in the sample collected at a depth of 130 feet was noted in soil vapor monitoring well No. 39 (located in the southwestern portion of the monitoring network and west of extraction well VE-04).
- Based on the asymptotic levels of influent Freon 113, CCl_4, TCE, and PCE concentrations, it appears that the SVE system operation at extraction well VE-04 has successfully reduced the concentrations of VOC in the subsurface within the radius of influence of extraction well VE-04 and as well as TCE concentrations in soil vapor monitoring well No.39 to the extent possible. Therefore, GEOFON recommends that the SVE pilot test be discontinued at extraction well VE-04 and the trailer-mounted SVE system be moved to the next extraction well location VE-02.

  As part of the SVE system operation rotation program (i.e. treatment of different areas using a rotating approach), the trailer-mounted SVE system shall be moved back to the extraction VE-04 location in future for concentration rebound evaluation.

5.0 PROFESSIONAL WARRANTY

Our professional services have been performed using that degree of care and skill ordinarily exercised under similar circumstances by other geologists, hydrogeologists and engineers practicing in this field. No other warranty, expressed or implied, is made as to the professional advice in this report.